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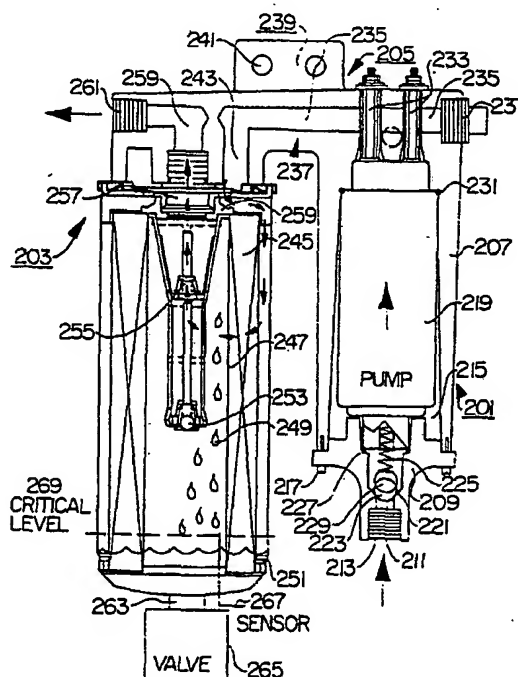
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(54) Title: FUEL FILTER AND SEPARATOR WITH BYPASSABLE BOOST PUMP

(57) Abstract

A fuel filter and boost pump apparatus including a filter chamber (203), a fuel filter (247) on the inside of the chamber, and a fuel pump (201) on the outside of the chamber. The chamber has a bottom mounted remotely actuated discharge valve (265). The fuel pump is in fluid connection with the inlet of the fuel filter by means of valves (223, 309). When the fuel pump is not running, these valves cause the fuel flow to bypass the pump and directly enter the inlet of the filter. A water sensor (267) detects water within the filter chamber. The remotely actuated solenoid discharge valve is operated when the water sensor detects a critical level (269) of water in the chamber.



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FUEL FILTER AND SEPARATOR WITH
BYPASSABLE BOOST PUMP

Technical Field

The present invention relates to an apparatus for filtering fuel used in internal combustion engines. More particularly, the present invention relates to apparatus that separates air and water contaminants from the fuel.

Background Art

The diesel engine is an internal combustion engine that differs from the gasoline engine principally in that it relies on heat generated by compressing air in a cylinder to ignite the fuel, rather than on an electric spark. To generate the required heat, the diesel must produce higher compression than the gasoline engine, thereby making it bulkier, heavier and more expensive. The diesel engine also operates more cheaply, on less highly refined fuel, which can give it an advantage in transportation and construction-equipment applications such as locomotives, trucks, tractors, buses, bulldozers, graders, and other heavy-duty machines, and in marine propulsion.

Although two English engineers have patented engines that did not depend on spark ignition, Rudolf Diesel of Germany conceived his invention as an improvement on the gasoline engine that fellow-German Nikolaus Otto had developed in 1876. Seeking to increase the efficiency of the Otto engine, it occurred to Diesel that he could do away with electrical ignition if he could compress air to so small a volume that the temperature would be above the ignition point of an appropriate fuel. The cycle of operation he conceived was set forth as follows: (1) air is drawn into the cylinder as the piston moves away from the cylinder head (intake); (2) the air in the cylinder is compressed by the piston as it moves upward toward the cylinder head (compression); (3) when the piston reaches the top of its stroke, the fuel charge is injected into the cylinder, where it is ignited by the high temperature of the compressed air. The fuel is injected at such a rate that the maximum cylinder pressure

35 never exceeds the pressure obtained by the compression of the air. After completion of the fuel injection the piston continues to move away from the cylinder head in its downward or expansion stroke (power); (4) the burned fuel is forced from the cylinder by upward motion of the piston (exhaust).

40 In 1892-93, Diesel took out patents on an engine to operate on the cycle just described. Either powdered coal or liquid petroleum would be used as fuel. Diesel planned to use compressed air to introduce the coal dust into the engine cylinder but found it difficult to control the rate of injection so that the maximum pressure in the cylinder after ignition would
45 not exceed a safe limit. After the experimental engine was wrecked by an explosion in the cylinder, Diesel gave up the idea of using the coal dust and devoted his efforts to the use of liquid petroleum.

50 The first commercial engine built on Diesel's patents was installed in St. Louis, Missouri by brewer, Adolphus Busch, who had seen one on display at an exposition in Munich and had purchased a license from Diesel for the manufacture and sale of the engine in the United States and Canada. The engine operated successfully for many years and was the forerunner of the Busch-
55 Sulzer engine that powered many submarines in the U.S. Navy in World War I. The diesel engine was economical in the use of fuel and it proved itself reliable under wartime conditions. Diesel fuel, less volatile than gasoline, was more easily stored and handled.

60 A diesel engine is started by driving it from some external power source until conditions have been established under which the engine can be run under its own power. The most positive starting method is by admitting air at 250 to 350 p.s.i. to each of the cylinders in turn under normal firing stroke. The
65 compressed air becomes heated sufficiently to ignite the fuel. There are many other methods of starting the diesel engine. The selection of the most suitable starting method depends upon the physical size of the engine to be started, the nature of the connected load, and whether or not the load can be disconnected
70 during starting.

Petroleum products normally used as fuel for diesel engines are distillates composed of heavy hydrocarbons, with at least twelve to sixteen carbon atoms per molecule. These heavier distillates are taken from crude oil after the more volatile portions used in gasoline are removed. The boiling points of these heavier distillates range from 350 degrees to 650 degrees Fahrenheit. Thus, their evaporation temperature is much higher than that of gasoline that has fewer carbon atoms per molecule. Specifications for diesel fuels published in 1970 listed three grades: the first was a volatile distillate recommended for high-speed engines with frequent and wide variations in load and speeds; the second, a distillate for high-speed engines in services with high loads and uniform speeds; and the third, a fuel for low- and medium-speed engines in services with sustained loads.

Water and sediment in fuels can be harmful to engine operation; clean fuel is essential to efficient injection systems. Fuels with a high carbon residue can be handled best by engines of low-speed rotation. The same applies to those with high ash and sulfur content. The octane number, which defines the ignition quality of a fuel, is ascertained by adjusting a mixture of octane and alpha-methyl-naphthalene until it has the same ignition quality as the fuel being tested. The percentage of octane in this mixture is then the octane number of the fuel under test. Despite all the efforts to develop and sell high quality diesel fuel, there remains a high level of water content and other impurities within the diesel fuel.

In the operation of diesel powered trucks, automobiles, and marine vehicles, it is a common problem that excessive water will appear in the fuel and that the user of the vehicle will occasionally run out of diesel fuel. When the operator of a diesel vehicle runs out of fuel, air is suddenly injected into the fuel line and into the system. When this happens, the user must continue to operate the starter until there is a significant chance that the starter will "burn up". Alternatively, the owner will have to call a service station or wrecker service so as to bring the car to the service station so that the fuel chamber can

be properly "bled", the fuel filter primed, and the engine properly started. Under normal conditions, such a procedure is tedious and difficult to accomplish by the owner of the vehicle. Additionally, where there is a large amount of water contaminant in the fuel, the owner of the vehicle will be unlikely to take the necessary steps to remove the accumulation of water from the fuel chamber. Typically, the diesel vehicle will be disabled because of the accumulation of water in the fuel chamber. Under these circumstances, the owner of the vehicle will incur large maintenance fees and will have a diesel vehicle that is inoperable until proper repair is implemented.

Many inventors have developed an apparatus for filtering fuel to remove both particulate matter and water.

U.S. patent number 2,503,566 issued to A.S.B. Scott on April 11, 1950 teaches a filter with a mechanical valve that can drain water from a tank. This allows the sump of a filter to be cleaned and flushed without dismantling the filter.

U.S. patent number 4,224,157 issued September 23, 1980 to K.K. Jain teaches a particulate to filter.

U.S. patent number 4,321,136 issued March 23, 1982 to K. Matsui for a fuel filtering device teaches the use of sensors to heat fuel to prevent the build-up of wax.

U.S. patent number 4,437,986 issued on March 20, 1984 to Charles Hutchins, et. al. teaches a separating device for separating water from a liquid mixture which uses an annular coalescing medium. This invention also teaches temperature control to prevent wax build-up and provides for a pressure bypass to allow the liquid to bypass the filter after a set pressure across the filter element is reached.

U.S. patent number 4,539,109 issued September 3, 1985 to L.L. Davis for drain system for fuel processor apparatus teaches the use of an automatic control means to control the separation of water from fuel. Davis teaches a sensing means for detecting the presence for predetermined amount of water or other impurities and a electrically controlled drain means to maintain the water or other impurities below a predetermined level. Davis also teaches a heater means to prevent wax build-up.

145 U.S. patent number 4,637,351 issued January 20, 1987 to B.J. Pakula for a system for removal of water from diesel fuel systems, teaches the use of a solenoid operated valve to allow the discharge of water from a gravity fuel separator.

150 The international patent application published June 29, 1989 under the Patent Cooperation Treaty number WO-89\05685, by the present inventor, teaches a fuel filter apparatus which includes a solenoid operated dump valve and a fuel pump attached to a chamber. Despite all of the work of inventors in this crowded prior art, it is clear that there are still several problems 155 which have not been solved by those skilled in the art. Foremost among these problems is the fact that filters introduce an undesirable obstruction in the fuel line.

160 It is desirable to use a boost pump to increase the pressure of fuel flowing through the filter, especially when the engine is starting or when water is being expelled from the filter chamber. All prior art known to the present inventor which incorporates such a boost pump requires that the fuel flow through the boost pump even when the boost pump is not operating, thus introducing a undesirable fuel flow restriction into the 165 fuel line.

It is an object of the present invention to provide a fuel filter that allows the accumulation of water to sensed and removed by remote actuation.

170 It is another object of the present invention to provide a fuel filter with a boost pump whereby fuel flows through the boost pump only when the pump is operating.

Another object of the present invention is to provide a fuel filter, separator and boost pump that reduces engine maintenance requirements.

175 It is still a further object of the present invention to provide a fuel filter and separator which allows the operator to restart the vehicle after running out of diesel fuel.

180 These and other objects and advantages of the present invention will become apparent from a reading of the attached specification of the pending claims.

Summary of the Invention

The present invention is a fuel filter and separator including a boost pump that comprises a chamber, a discharge valve, a fuel pump and a fuel filter. The discharge valve is electrically operatable and is connected to an electronic control means. These electronics are also connected to a water sensor in the lower part of the filter chamber. The fuel pump is connected to the fuel filter through check valves that allow fuel to flow through the pump when the pump is operating and allow fuel to flow directly into the inlet of the filter when the pump is not operating. The discharge valve for the selective discharge of contaminant fluid from the chamber is connected to the bottom of the filter chamber. The fuel pump, typically, is connected to the fuel line of the vehicle. The fuel pump is connected to the fuel line through a check valve. The boost pump of the present invention is capable of generating a higher fluid pressure at its output than the pressure supplied to the boost pump fuel inlet by the fuel pump of the vehicle. Thus, when the boost pump of the present invention is turned on, its output pressure overcomes the fuel pressure acting on a check valve which closes a fuel bypass line and causes fuel to flow through the boost pump into the fuel filter.

The output of the boost pump is in fluid communication with the inlet of the fuel filter. The fuel filter is a commercially available filter that uses a coalescer media, such as the Fram 5000 Series. These filters have an internal filter element housed within a chamber. The chamber which has a threaded drain hole at its bottom. In the present invention, a remotely actuated solenoid valve is attached to the drain opening of the filter. A sensor that detects water level within the chamber is also inserted into the chamber through the drain plug opening. Both the water level sensor and the solenoid actuated valve are connected to electronic control means. The electronic control means allows: 1. the valve to be manually operated to dump the water from the chamber; 2. allows the fuel boost pump to be operated manually to restart the diesel engine if air contaminant has gotten into the fuel line; and 3. allows the automatic

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operation of the solenoid dump valve when a predetermined level of water is detected in the filter chamber.

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220 Brief Description of the Drawings

Figure 1 is a block diagram showing the present invention within the fuel system of an internal combustion engine.

Figure 2 is a front view of the boost pump and filter apparatus of the present invention shown in partial cross
225 sectional cut away.

Figure 3 is a detail of the pump section of the present invention showing the check valves and fuel bypass channel.

Figure 4 is a block diagram of the electric control means of the present invention.

230 Figure 5 is the schematic diagram of the electronic control circuit of the present invention.

Detailed Description of the Invention

Figure 1 shows a functional block diagram of the present invention in a fuel system for a diesel engine.

235 Fuel tank 101 is connected by fuel line 103 to an in-line disposable filter 105. This is typically either a 2 1/2" or 5" disposable cartridge filter that removes gross particulate matter from the fuel flow. This filter does not remove fine particulate matter or liquid impurities, such as water from the fuel. The
240 output of disposable filter 105 is in fluid communication through fuel line 107 with boost pump filter separator 109. The output of the present invention, 109, is in fluid communication through fuel line 111 with the main fuel pump 113 of the system.

The outlet of fuel pump 113 is in fluid communication
245 through fuel line 115 with the fuel inlet of diesel motor 117.

The present invention may be located downstream from the fuel pump, as shown in Figure 1 or upstream from the fuel pump. If the invention is located upstream from the fuel pump, then the pressure generated by the boost pump of the present invention
250 must exceed the pressure produced by the fuel pump of the fuel system.

Although it is generally anticipated that the present invention will be most useful on apparatus such as trucks, bulldozers or stationary engines which use diesel prime movers,
255 it may also be used to remove impurities and water from the fuel flow to a gasoline engine.

Figure 2 shows a front partially cut away view of the mechanical structure of the present invention.

In Figure 2 the invention is shown generally as pump section
260 201 and a filter section 203, which are joined by a fuel passage 205.

Pump section 201 provides a cast aluminum pump housing 207. Housing 207 has a bottom plate 209 which is drilled and tapped to provide a fuel passage 211 from a threaded inlet 213 to the
265 interior of 215 of pump chamber 207. The bottom plate 209 is affixed in hermetic sealing contact by threaded screws 217 to the bottom of chamber housing 207.

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Fuel pump 219 is in the interior 215 of pump chamber housing 207.

270 Inlet 213 is in fluid communication with pump 217 through channel 211. Channel 211 is equipped a tapering side section 221 which is adapted to fit ball valve 223. Ball valve 223 is biased into the closed position by spring 225.

275 Channel 211 is maintained in a hematic sealing engagement with the interior of pump 219 by o-ring seals 227.

Ball valve 223 is held normally shut by bias spring 225. When fuel flow at normal fuel pressure is introduced into inlet 213, then ball valve 223 moves to the open position shown at 229, which allows the fuel to flow into the pump and fuel bypass channel described in Figure 3 below.

280 Motor 219 is hermetically sealed to the top portion of chamber 207 by means of o-ring seal 231. The electric motor of pump 219 is connected through electrically insulated connectors 233 which penetrate the top of case 207 and thence an external source of electric power which is controlled by the electronic control means of the present invention, not shown. The upper part of housing 207 is provided with a fluid flow passageway 235 which is sealed at one end by threaded plug 237. Passageway 235 is in fluid communication with the fluid input of pump 219.

285 Housing 207 of pump assembly 201 is connected by a aluminum manifold 237 to filter section 203. Fuel flow passageway 235 penetrates manifold section 237. Manifold section 237 is also provided with a bracket 239, which is provided with holes 241 for mounting the pump and filter assembly of the present invention on a suitable mechanical support means, not shown.

290 Fuel passage 235 is in fluid communication with filter inlet annulus 243. Annulus 243 is in fluid communication with the coalescar media 245 of filter 247. Filter 247 is a commercially available filter such as a Fram Series 5000 fuel filter/water separator. This type of fuel filter allows the fuel to enter by an inlet and then flows the fuel through the filter and coalescar media. The coalescing action forms larger droplets of water as smaller ones come together. The fuel then passes through a silicone treated nylon mesh separator 247. The water droplets

305 249 drop into the bottom of the filter housing 251. The dry fuel then passes through ball check valve 253.

Then entire filter is attached to and placed in fluid communication with the annulus 243 by means of a well known threaded fuel filter attachment fitting 257. The fuel filter has
310 internal o-ring seals 259 to maintain fluid integrity of the filter system.

The dry fuel exiting filter through outlet 255 passes into an internal fuel outlet channel is in fluid communication with fuel outlet channel 259 which, in turn, is in fluid communication
315 with the fuel outlet 261 of the present invention.

The filter 247 is provided with a threaded drain plug opening 263. The present invention attaches to this drain plug opening and places in fluid communication with it a fuel dump valve 265, which is an electrically operated solenoid valve. The
320 valve assembly of the present invention is equipped with a water level sensor 267 which is capable of detecting water at critical level 269.

Figure 3 shows a side view of the pump section 201 of the present invention which shows the valves and fuel bypass passage
325

In Figure 3, numbers which are the same as those used in Figure 2 indicate the same structures, while figures that begin with the number 3 indicate structures which are shown only in Figure 3. Figure 3 shows the pump section 201 of the present invention. In Figure 3 flow channel 211 is shown to be in fluid communication with fuel bypass channel 303, which is sealed at one end by plug 305. This fluid flow channel is in fluid communication with bypass channel 307, which allows the flow of fuel through check valve 309 which is normally biased closed by spring 311, into fuel outlet channel 235.
330

The top of bypass channel 307 is sealed by threaded plug
335 313.

All of the walls and passageways of the present invention are preferably but not necessarily made of cast aluminum. The inventor considers all of the machining required by the present invention to be within the skill of the art of a skilled
340 machinist.

Functionally, fuel enters inlet 213 and is impelled under either atmospheric pressure or the pressure of an external fuel pump to open check valve 223 into position 229, thus allowing the flow of fuel through bypass channel 303 to main bypass channel 307 and then through check valve 309 and out of the main fuel passageway 235. The fuel then passes into the filter 247 through annulus 243. The fuel and water are separated by the passage through coalescar medium 245. The water accumulates at the bottom 251 of filter chamber 247. The water level is sensed by sensor 267. When the water reaches critical level 269, the electronic control means operates electrical solenoid valve 265 and causes the water to be dumped.

When fuel pump 219 is operating, then the pressure from the outlet 237 of pump 219 causes check valve 209 to seal against valve seat 239. When check valve ball 309 seals against valve seat 339, it prevents the flow of fuel through bypass line 307. Fuel then flows through pump 219 into outlet passage 235 and thus into fuel filter 247 when water and fuel are separated as described above.

Figure 4 is an block diagram of the control means of the present invention.

In Figure 4 control electronics 401 are connected to a source of electrical power 403 through power line 405. The control electronics accepts an input from sensor 267 and also an input from control switches 407. The control electronics actuate the water dump valve 265 and the boost fuel pump 219.

Figure 5 is a detailed electrical schematic of the electronic control means of the present invention. This schematic may be read by anyone having ordinary skill in the art of electronics and thus will not be described further.

The control switch 407 may be actuated to manually dump water from the present invention or to manually operate the pump to allow a engine which has run out of fuel or has impurities in its fuel line to purge the fuel line. Alternatively, the control switch may be set in an automatic mode which allows sensor 267 to control when water is dumped by the system.

In the dump mode of the present invention, the control electronics runs the pump for 4 seconds to overcome the negative pressure of the fuel flowing from the main fuel source. The dump valve is then opened and the water fuel mixture is then expelled from the dump valve for 4 seconds.

In the purge mode the fuel pump is operated for 1 1/2 minutes. All of this timing is accomplished by the electrical means shown in Figure 5.

The present invention is capable of allowing fuel to flow without any restriction through the filter and still is capable of allowing a boost pump to be used to purge the filter or purge the fuel line.

Although the best embodiment of the invention known to the inventor has been shown in the above specification, it should not be considered limiting. There are many ordinary mechanical changes that can be made to this invention, therefore the above specification should be considered as illustrative only and not as limiting. The invention should be limited only by the appended claims and their equivalents.

Claims

1. A fuel filter/separator with bypassable boost pump apparatus comprising:
- 400 a chamber having a fluid inlet, a fluid outlet and a bottom fluid drain;
- 405 filter means for removing impurities from a flowing liquid, said filter means being disposed within said chamber, said filter means further being in fluid communication with and disposed in fluid series circuit between said inlet and said outlet;
- 410 fluid pump means for pumping a fluid, said pump means having a fluid inlet and a fluid outlet, said pump inlet being in fluid communication with a supply of liquid and said pump outlet being in fluid communication with the inlet of said filter means;
- 415 at least one fluid bypass channel means having a beginning and an end for allowing liquid to bypass said pump means, the beginning of said bypass channel means being in fluid communication with said pump inlet;
- 420 bypass valve means for preventing fluid flow through said bypass channel when said pump means is pumping, said valve means being disposed between and in fluid communication with said end of said bypass channel means and said outlet of said pump means; and
- 425 dump valve means for selectively controlling fluid flow, said dump valve means being in fluid communication with said chamber bottom drain.
2. An apparatus as in Claim 1 including:
- 430 sensor means for detecting fluid impurities in said chamber, said sensor means being located approximate to said bottom drain; and
- control means responsive to said sensor means for controlling pump means and said dump valve means.
3. An apparatus as in Claim 2 wherein the valve means comprises a spring loaded check valve in fluid communication with the bypass channel means and the

outlet of said pump means;

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said check valve being adapted to permit the flow of fluid from the bypass channel into the pump outlet when the fluid pressure in the bypass channel is higher than the fluid pressure at the pump outlet.

4. An apparatus as in Claim 3 including a second fluid check valve in fluid communication with the pump inlet and adapted to permit the flow of fluid from said source of liquid into said pump inlet and into said bypass channel when the fluid pressure in the pump inlet and bypass channel are lower than the fluid pressure from the liquid source.

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445

5. An apparatus as in Claim 4 wherein the chamber and filter means are a commercially available disposable filter cartridge using a coalescar medium; the chamber inlet and outlet is a cast manifold adapted to screwingly and hermetically engage said commercially available filter; said bottom drain is an opening in the bottom of the commercial filter;

450

said pump means is an electric boost pump;

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said fluid bypass channel means is a channel located approximate to the electric boost pump and in fluid parallel circuit with said pump, said fluid bypass channel having at least one tapered section;

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said bypass valve means is a spring loaded ball check valve located within the bypass channel, the diameter of said check ball being adapted to sealingly engage the tapered section of the channel, check valve being oriented so as to permit the pass of fluid from the pump inlet end to the pump outlet end when the fluid pressure at the pump inlet is greater than the fluid pressure at the pump outlet;

465

said dump valve means is a electrically controlled valve;

said sensor means is a water level sensor;

470

said control means is an electric timing circuit

475480

responsive the sensor means and further responsive to manual control by switch means for changing the state of the control means whereby the boost pump may be operated manually at a cycle approximately 1 1/2 minutes, the valve and pump may be operated manually to pump fluid through the dump valve on a cycle of approximately eight seconds of pump actuation with the last four seconds of this period including opening of the dump valve, and the system may be operated automatically to turn on the boost pump and open the dump valve when the sensor detects a critical level of fluid impurity at the bottom of the chamber.

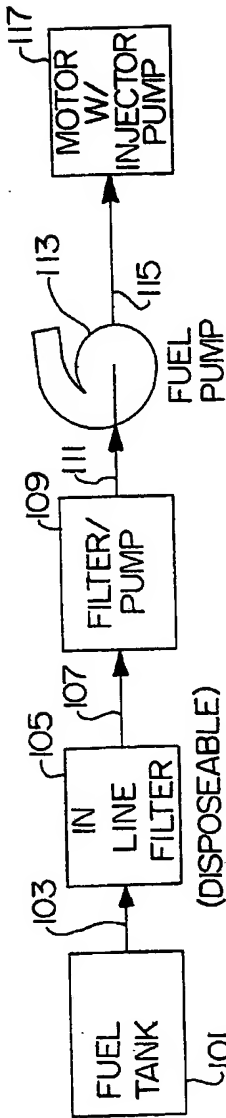


FIG. 1

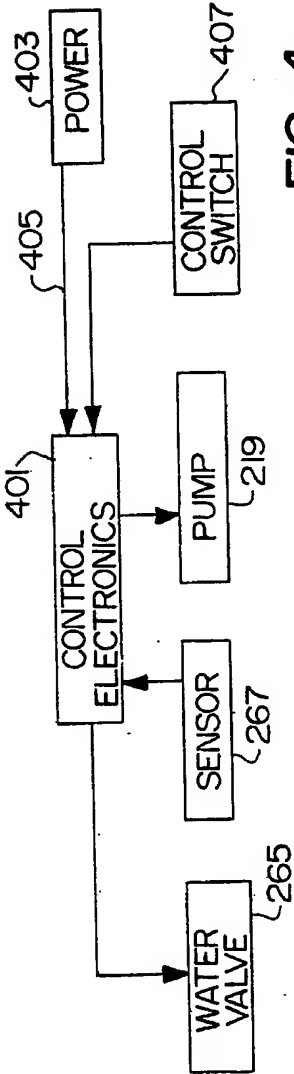


FIG. 4

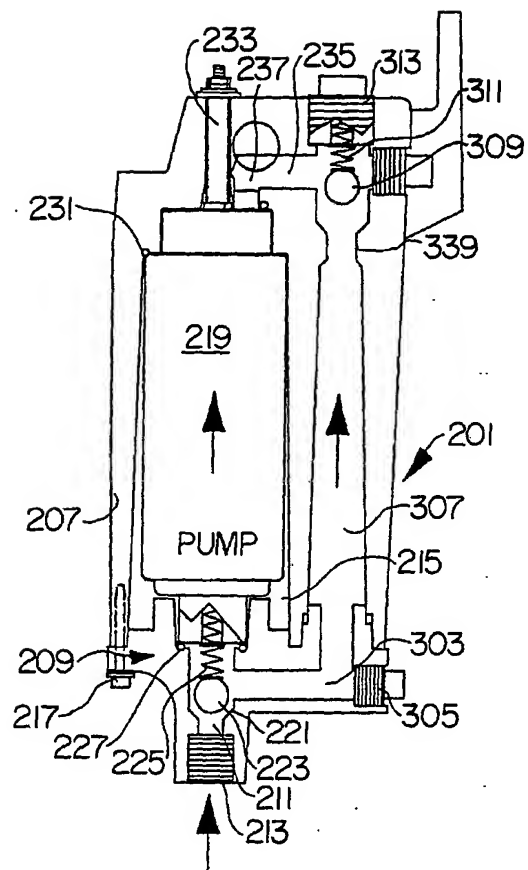


FIG. 3

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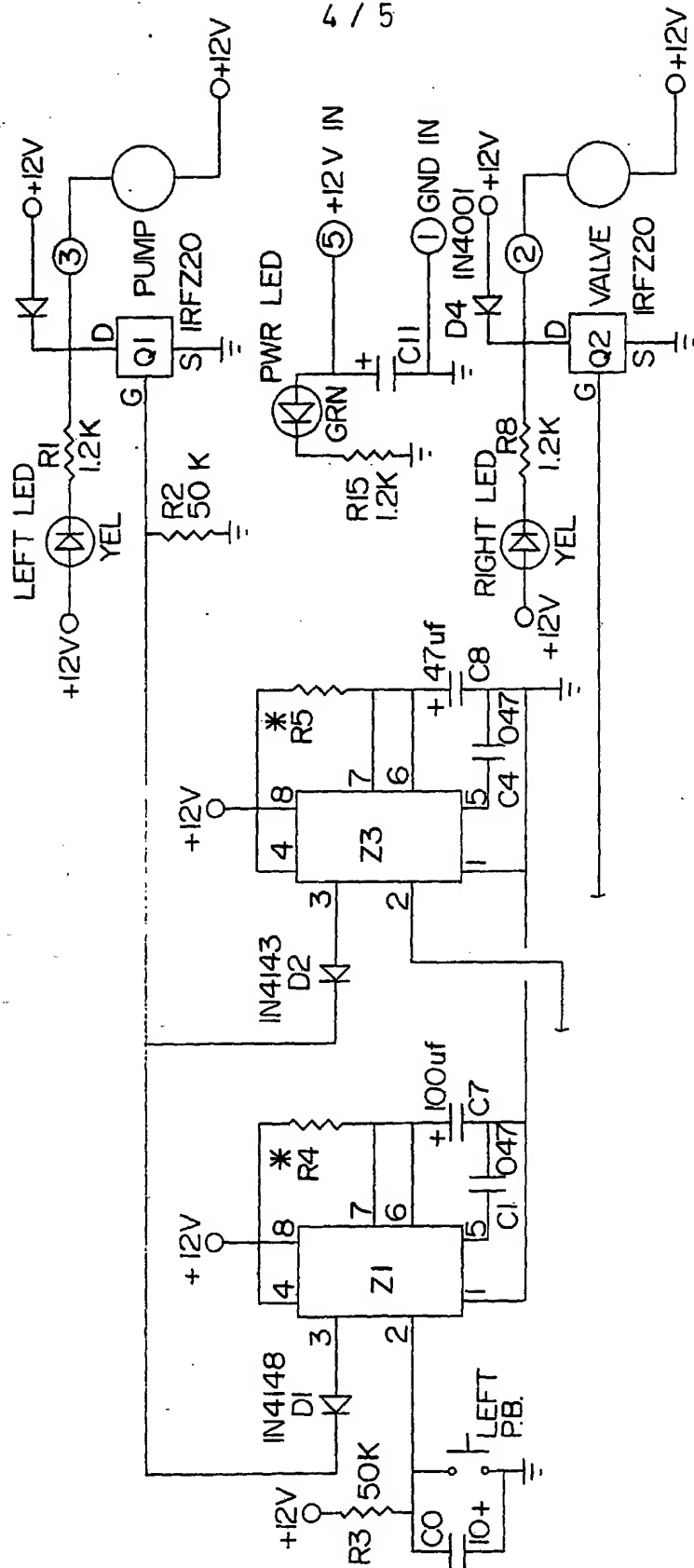


FIG. 5A

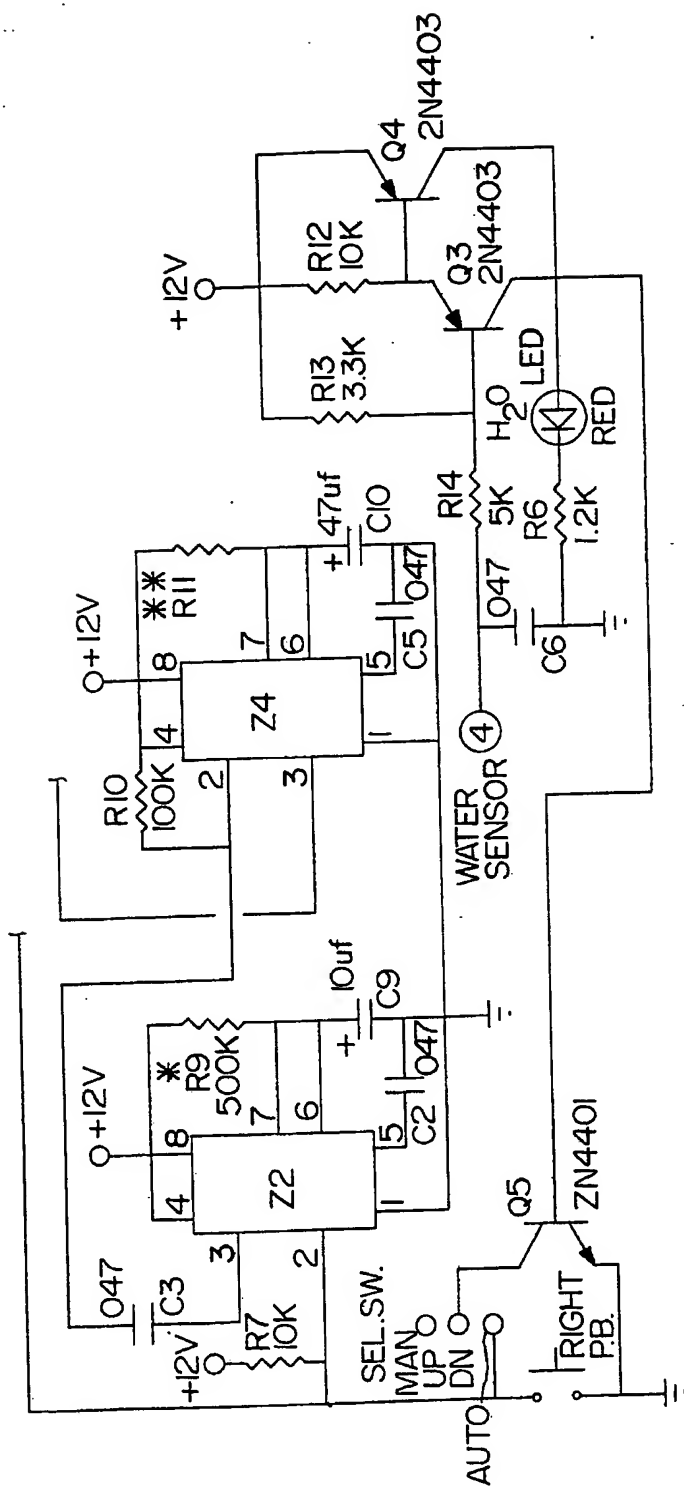


FIG. 5B

INTERNATIONAL SEARCH REPORT

International Application No. PCT/US91/04995

I. CLASSIFICATION OF SUBJECT MATTER (if several classification symbols apply, indicate all) ⁶		
According to International Patent Classification (IPC) or to both National Classification and IPC		
IPC(5): B01D 17/02, 17/12, 27/10		
US CL.: 210/114, 136, 138, 143, 313, 416.4		
II. FIELDS SEARCHED		
Minimum Documentation Searched ⁷		
Classification System	Classification Symbols	
U.S.	210/112, 114, 136, 138, 143, 302, 312, 313, 416.4	
Documentation Searched other than Minimum Documentation to the Extent that such Documents are Included in the Fields Searched ⁸		
III. DOCUMENTS CONSIDERED TO BE RELEVANT ⁹		
Category ¹⁰	Citation of Document, ¹¹ with indication, where appropriate, of the relevant passages ¹²	Relevant to Claim No. ¹³
<u>X</u> A	US, A, 4,500,425 (THORNTON ET AL) 19 FEBRUARY 1985 (See from line 62 of column 1 to line 6 of column 4.	<u>1</u> 2-5
<p>* Special categories of cited documents: ¹⁰</p> <p>"A" document defining the general state of the art which is not considered to be of particular relevance</p> <p>"E" earlier document but published on or after the international filing date</p> <p>"L" document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified)</p> <p>"O" document referring to an oral disclosure, use, exhibition or other means</p> <p>"P" document published prior to the international filing date but later than the priority date claimed</p> <p>"T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention</p> <p>"X" document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step</p> <p>"Y" document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art.</p> <p>"&" document member of the same patent family</p>		
IV. CERTIFICATION		
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